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Bon Appétit: Acquiring Food Preparation Skills via Virtual Simulation

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Abstract: *Life skills represent important skills needed for students with intellectual and developmental disabilities (IDD). Technology, including immersive and non-immersive virtual reality, presents options to support the acquisition and maintenance of life skills for students with IDD. In this study, researchers examined a non-immersive virtual simulation module for delivering life skills instruction to high school students with IDD, with particular attention on food preparation—making grilled cheese on a stove. In the single subject multiple probe study with three participants, the researchers found two main results: (a) a functional relation between the intervention—virtual simulations for delivering life skills instruction—and the dependent variable of independent accuracy in making a grilled cheese sandwich on a stove, and (b) students maintained high levels of accuracy in their targeted skill (i.e., making a grilled cheese on a stove) after instruction ended.*

Daily living skills, also known as independent living skills or life skills, are skills needed for individuals to live, work, and have fun within an inclusive society (Bouck et al., 2015). Life skills are critical for all individuals, including individuals with intellectual and developmental disabilities (IDD) who can struggle with living independently (Bridges et al., 2020; Westling & Fox, 2004). There are multiple skills that encompass life skills, often grouped into six domains: community participation (e.g., transportation), employment, self-care, domestic learning (e.g., cooking, cleaning, shopping, hygiene), social interaction (e.g., social skills), and recreation and leisure (Clark et al., 1994).

Life Skills Interventions

Researchers teaching life skills to students with IDD have used a variety of interventions. Older studies, per a review by Lancioni and O'Reilly (2002), suggested significant attention in independent living skills research to pictorial-based prompting systems and time delay prompting procedures. Researchers also suggested classroom simulations in which a natural context or environment was approximated an effective intervention when instruction of life skills within natural settings was challenging (Rowe et al., 2021; Rowe & Test, 2012). In recent decades, greater attention existed towards more advanced technology as an intervention to support teaching daily living skills, including video modeling or prompting, augmented or virtual reality, and online games (Montoya-Rodriguez et al., 2023; Stierle et al., 2022).

One of the most popular and widely used interventions for teaching daily living skills to students with IDD is video-based instruction, which encompasses video modeling and video prompting (Kellems & Edwards, 2016; Park et al., 2019). Video modeling involves students watching a short video of a skill being performed and then subsequently performing the skill themselves; video prompting involves students watching a video broken into steps and performing each step after watching the video clip (Alberto et al., 2005; Cannella-Malone et al., 2011). Throughout the years, researchers have evaluated and validated video-based instruction (VBI) as an evidence-based practice for

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students with IDD. Domire and Wolfe (2015) concluded video modeling was an evidence-based practice for teaching daily living skills to students with IDD. More specifically, and using different criteria, Rowe et al. (2021) determined video modeling to be an evidence-based practice for daily living skills related to home maintenance and a research-based practice for food preparation and leisure skills. Most recently, Stierle et al. (2022) determined video prompting and video modeling on mobile devices to be evidence-based practice to teach daily living skills to students with intellectual disability.

Despite the success of video modeling and prompting, researchers also examined other technological interventions to support life skill acquisition, such as augmented reality and virtual reality. Augmented reality (AR)—an immersive, authentic environment (Bower et al., 2014)—has also been used to successfully teach daily living skills. For example, Cihak et al. (2016) used AR to successfully help three students with autism spectrum disorder (ASD) acquire and maintain the skill of independently brushing their teeth. Similarly, McMahon et al. (2013) found seven students with IDD successfully acquired and maintained the skill of identifying potential food allergens via AR. More recently, Bridges et al. (2020) examined AR to deliver video modeling to support adults with IDD to learn daily living skills including ironing, making the bed, and setting an alarm clock. The individuals all achieved the preset mastery criterion following AR-delivered instruction.

Researchers have investigated virtual reality (VR)—often focused on a three-dimensional digital environment—as a means of providing instruction in daily living skills to students with IDD (Cheung et al., 2022; Kavanagh et al., 2017). Panerai et al. (2018) explored VR to support young adults and adolescents with IDD across such life skills as taking medicine on time, packing for a trip, and grocery shopping using a list. Across the different skills examined, the number of errors made by participants decreased and the number of correct responses increased. Cheung et al. (2022) also examined VR as a means of teaching life skills (i.e., grocery shopping, cooking, and cleaning) to individuals with IDD. The participants were randomized across three conditions: VR, traditional instruction, and control. Those in the VR and traditional instruction conditions both improved their skills relative to their demonstration of the daily living skills and the participants positively reported on the VR.

Food Preparation

Although all daily living skills add value to quality of life, food preparation directly connects to living independently (Bridges et al., 2020). The existing literature examining food preparation instruction for students with IDD suggests a variety of effective interventions, including the aforementioned use of technology (e.g., video modeling, AR; Cihak et al., 2016; Mousa AL-Salahat, 2016; Taber-Doughty et al., 2011). Food preparation is a varied, diverse, and large area within daily living skills. Much of the existing research related to food preparation has focused on microwaves (e.g., Bereznak et al., 2012; Sigafoos et al., 2005; Van Laarhoven & Van Laarhoven-Myers, 2006). Yet, to live full and independent lives individuals need to use appliances other than a microwave, such as a stove and oven. A stove/oven is reported as one of the top five appliances owned and using one can reduce the reliance on convenient and fast foods, which are commonly associated with microwaves (Oakley et al., 2019).

Ayres and Cihak (2010) examined VBI to teach students with ID to make a sandwich, use a microwave, and set a table. Across the 10-step task analysis for using a microwave, Ayres and Cihak found students increased in the number of steps they completed in order. While the students decreased during maintenance, they increased to intervention levels with one additional boost session of VBI. Similarly, Johnson et al. (2013) found a teacher successfully implemented video prompting to teach two high school students with IDD to engage in three food preparation tasks—making a smoothie, making mac-and-cheese in a microwave, and cooking pizza in a microwave. Similarly, Payne et al. (2012) found two students with IDD successfully acquired the skill of using a microwave to make popcorn via video prompts.

While less extensive within the literature, researchers have explored using the stove or oven to prepare food. Kanfush and Jaffe (2019) examined teaching students with IDD

food preparation skills via video modeling, including targeting use of the stove or oven (e.g., making pasta, scrambled eggs). The participating students increased their independence in completing their targeted food preparation skills and three of the four maintained their skills after a month following the video modeling intervention (Kanfush & Jaffe, 2019). Stierle et al. (2023) also examined video modeling as an intervention to support three young adults with IDD in cooking on a stove (e.g., mac-n-cheese, veggies). The video modeling intervention increased students' independence with the cooking tasks.

Current Study

Life skills are important skills needed by all individuals, including individuals with disabilities. Individualized education program (IEP) teams are required to address life skills during the secondary IEP with a transition plan beginning at age 16 (Yell, 2019). Researchers found approaches (e.g., in vivo instruction and technology-based) to be effective in supporting life skills acquisition for students with IDD (Lappa & Mantzikos, 2023). This study focused on instruction via virtual simulations. Researchers addressed the following research questions: (a) Are secondary students with IDD able to increase in their independent accuracy in completing a targeted life skill (i.e., making a grilled cheese sandwich on the stove) through instruction received within a virtual learning simulation and the system of least prompts (SLP)?; (b) Are secondary students with IDD able to maintain their accuracy in the targeted life skill?; (c) Are secondary students with IDD able to generalize their acquisition of a targeted life skill via the virtual simulation to another life skill (i.e., making pizza in the oven)?; and (d) What are teacher and student perceptions of the virtual life skills learning simulation?

Method

Participants

Three students with IDD participated in this study. All three students were educated in the same self-contained program focused on students with IDD in a midwestern high school. The students were taught by the same special education teacher, who supported them in life skills and transition. Researchers established the following inclusion criteria for the study: (a) secondary student with IDD, (b) identified need to acquire life skills per teacher recommendation, (c) ability to use a touchscreen computer and follow directions, (d) scored less than 50% on the stove pre-screening, and (e) had no prior exposure to the virtual life skills simulations. Researchers obtained parental consent and student assent for all participants. Within the online modules, all three of the students demonstrated success during pre-training with using the microwave to heat up pizza rolls and changing a lightbulb.

Paul

Paul was a 17-year-old, white, male junior in high school. Paul was identified with an intellectual disability (ID), with a reported IQ of 54. Paul was predominantly educated in the self-contained special education program; he attended a general education class for one class period per day. Paul had IEP goals related to ordering food for himself in a restaurant and developing self-advocacy skills related to explaining his disability to others. He also had post-secondary education goals related to researching real estate jobs and practicing interview skills.

Julia

Julia was a 16-year-old, white, female, sophomore in high school. She also predominantly attended the self-contained special education class and attended a general education class for one class period a day. She was identified with an ID and her IQ was reported as 68. She had IEP goals related to life skills in terms of hygiene (e.g., showering). Her transition post-secondary employment goals involved culinary skills, including exploring requirements to apply at restaurants and visiting the county culinary trades program for high school students.

Simone

Simone was a 15-year-old, white, female, freshman student. Her official special education

Figure 1. Screenshot of Making a Grilled Cheese Sandwich on a Stove Virtual Simulation. Source: Michigan Transition to Independence from the Michigan Association of Administrators of Special Education.

eligibility was listed as ID, although her reported IQ was 73. She attended the special education program for most of the day, leaving for one class period per day to attend a general education class. Given she was not yet 16, her teacher reported that she had no postsecondary life skills or employment goals written into her IEP.

Setting

The three secondary students with IDD all attended the same school and were taught by the same teacher. The school was a public high school in a rural mid-size town in the Midwest. The students were educated in a program designed for students identified with IDD. All instruction occurred in a separate, unused classroom across the hall from the students' special education classroom. The room had tables in a U-shape and desks within the center of the U. The researchers worked one-on-one with students at the tables, except in sessions when interobserver agreement (IOA) data were collected.

Materials

For this study, researchers used Chromebooks, data collection sheets, and the life skills virtual simulation that was loaded onto the Chromebooks via GooglePlay and accessible without internet access. The life skills modules on the virtual simulation were created through a partnership with the Michigan Association of Administrators of Special Education, Great Lakes Reality Labs (GLRL), and Public Policy Associates, and were paid for using state money. The life skills modules were developed in response to the COVID-19 pandemic as a means to continue to support students with IDD and other extensive support needs with life skills instruction when schools were online or remote. However, given the state served many rural and other high-need districts, in which access to in vivo life skills instruction was not always possible, the tool offered implications and value beyond the pandemic and remote learning. The life skills modules were only accessible with Chromebooks and Windows machines; the simulations were downloaded using Steam (Windows) or the Google Play Store (Chromebooks). The modules could be used with a track pad/mouse or a touchscreen. For the purposes of this study, students used the touchscreen and were able to physically touch items on the Chromebook to engage with the skill.

All three students engaged with the same life skills module—using a stove to make a grilled cheese sandwich, which was one of 11 available (see Figure 1). This task was targeted as the teacher identified each student as needing life skills connected to operating appliances. The task consisted of 32 steps associated with using the stove in the virtual simulation (task analyses available upon request from the first author). Generally, for the stove simulation, the steps needed to be done in the correct order (e.g., washing hands before preparing the food, buttering the bread before putting in the frying pan). The stove simulation was targeted as the researchers were interested in food preparation skills using an appliance;

however, during a skill acquisition pre-assessment, the students demonstrated high levels of accuracy when using a microwave. For generalization, researchers collected data on the simulation involving using an oven to make a frozen pizza, which involved 25 task analysis steps.

The data collection sheet consisted of the task analysis of the life skill used (stove for baseline, intervention, and maintenance; oven for generalization). Researchers developed a task analysis to complete for each life skill within the virtual simulations (available upon request from the authors). The researcher recorded whether students completed the task steps independently and accurate, inaccurate, or with a prompt. If with prompting, researchers collected the level of the SLP—gesture, indirect verbal, direct verbal, and modeling—on the data collection sheet. The data collection sheet allowed researchers to record independent accuracy, the number of prompts students received, and task completion time.

Experimental Design

In this study, researchers used a multiple probe across participants single case design to explore the relationship between life skills modules (i.e., using the stove to make a grilled cheese sandwich) with the SLP and students' independent accuracy in engaging in simulated life skill tasks. Following the multiple probe across participants design, all three participants began baseline at the same time and then systematically entered intervention in a staggered fashion (Ledford & Gast, 2018). To enter intervention, each student needed a minimum of three baseline sessions, in which the data were stable and zero-celerating or decelerating. Three baseline sessions, as a minimum, is consistent with the single case quality indicators and standards by the Council for Exceptional Children (2014; Cook et al., 2014). After the first student, each subsequent student entered intervention after at least one more baseline session than the previous student. Each student remained in intervention until they achieved 100% independent accuracy for two consecutive sessions on their targeted life skills task. When this was achieved, regardless of the number of sessions, participants ended intervention and entered the maintenance phase.

Independent and Dependent Variables

The independent variable in this study was the intervention package involving the virtual life skills module and the SLP. The life skills modules consisted of two modes: guided and independent. In the guided mode, students were given prompts and directions on the steps to complete the task from the virtual simulation itself. In the independent mode, which served as the dependent variable, students completed the task with minimal feedback but no instruction from within the program for most of the modules. Note, if a student picked up the sandwich without a spatula, they were told they burnt their hand and if they did not flip or remove the sandwich in time they were told the sandwich was burning and smoke would simulate. Researchers used the SLP during independent mode, which served as the probe for assessing the dependent variable during all phases. The SLP was used when students failed to initiate a step of the task analysis and not for inaccurate responses. The SLP consisted of four levels: gesture (e.g., referencing with one's hands to the external mouse or to a space on the screen), indirect verbal (e.g., "What do you do next?"), direct verbal (e.g., "Please touch the butter with the knife"), and modeling (e.g., the researcher demonstrating the step on the Chromebook).

The researchers collected data on multiple dependent variables. The primary dependent variable was the independent accuracy of students completing the life skill task. Researchers recorded independent accuracy as the number of task analysis steps completed accurately without prompts or assistance (e.g., wash hands, butter the bread, flip the sandwich, turn off the stove). Specifically, students could complete each step independently accurate, independently inaccurate, or accurate with prompting. Thus, independent accuracy involved the number of steps out of 32 total task analysis steps completed accurately and independently (i.e., without any prompts from the researchers). Researchers also collected data on the number of prompts

provided for each session and level of prompting required. Finally, researchers measured task completion time, which reflected the time students spent engaged in the independent mode of the life skills module.

Procedure

Four researchers participated in data collection. One was a faculty member in special education with experience conducting research both regarding life skills instruction for students with IDD and providing online intervention to students with disabilities. Two other researchers were graduate students in special education and/or educational psychology with experience working with students with disabilities. Finally, an advanced undergraduate student with experience working with individuals with IDD participated to collect inter-observer agreement (IOA) data. The primary researcher provided training to all other members of the research team.

Pretraining. Prior to baseline, researchers provided students with pretraining on the virtual simulation system. Researchers modeled how to access the virtual modules on their Chromebook and discussed the difference between the guided (i.e., instruction) mode and the independent mode, which was the probe for the dependent variable. The researchers demonstrated how to interact with the life skills modules and allowed students to practice on a module not associated with the study—putting groceries away in the kitchen. Researchers demonstrated how to engage with the module, such as clicking on an item to pick it up and clicking on a space to set it down. They also showed how clicking green circles moved someone to that space (e.g., fridge or cupboard). This demonstration included how to use the touchscreen component of the Chromebook.

Baseline. During baseline, researchers sat next to the student. The researcher pulled up the targeted module—using a stove—and students were instructed to complete the task of cooking a grilled cheese sandwich. The researchers indicated they would not provide any help and students should continue until they had finished or wanted to stop, by which they were to verbally tell the researcher they were done. During the baseline probe, students engaged with the module via independent mode, so the system provided no prompts, cues, or feedback. If a student had not completed the module within 5 minutes and did not verbally say they were done but were not engaging with the module, researchers ended the session to prevent frustration.

Intervention. During intervention sessions, students engaged with the module (i.e., making a grilled cheese on the stove) via the guided mode. During the guided mode of the module, instructions, prompts, and feedback from within the online system were provided to the student. It was during this guided mode that students explicitly learned to complete the skill. During each intervention session, students engaged with the targeted module once in the guided mode and worked on the task until they completed or refused to continue.

Immediately after the guided task, students completed the intervention probe (i.e., the dependent variable). The intervention probe consisted of students engaging in the targeted skill (i.e., using the stove to make a grilled cheese sandwich) in independent mode. Thus, the probe in intervention was the same as baseline probes, except researchers used the SLP during intervention if students failed to initiate a step within 10 seconds. Students were allowed to make an inaccurate response and no prompting was given, which researchers recorded as an independent inaccurate response. As such, the SLP was only used for times in which the student failed to engage.

Generalization. Throughout the study, students completed a generalization session every three sessions with the stipulation they did so at least once during each phase (baseline, intervention, and maintenance). During generalization sessions, students completed the virtual life skill module of using an oven to make a frozen pizza via the independent mode. Researchers collected data on accuracy (marked each task analysis step as completed independently accurately or independently inaccurate) and task completion time. Researchers did not use the SLP during generalization probes.

Maintenance. Students engaged in two maintenance sessions starting 1 week after the last intervention session. Students completed the maintenance session probes as they did intervention and baseline probes—through the independent mode. As in baseline, researchers collected data relative to if students independently and accurately completed the steps of the task analysis (yes/no) and task completion time. Researchers did not provide the SLP during maintenance sessions.

Inter-Observer Agreement and Procedural Fidelity

A second researcher was present for at least one third of baseline, intervention, and generalization sessions and half of the maintenance sessions. Both the primary and secondary researcher used the same data collection sheet and compared for independent accuracy at the end of each IOA session. To calculate, the primary researcher divided the number of agreements by the total number of opportunities to agree for each session. IOA for Paul was 87.5% during baseline, an average of 92.9% during intervention, 100% during maintenance, and an average of 97.3% for generalization. For Julia, IOA in baseline was 81.3%, an average 99.2% in intervention, 100% in maintenance, and an average of 96.2% during generalization. Researchers calculated IOA for Simone as 96.9% during baseline, an average of 92.2% during intervention, 100% during maintenance, and 100% during generalization.

When the second researcher was present, they also evaluated for procedural fidelity using a checklist. Researchers developed a checklist for both when students experienced the intervention session (i.e., engaged with the guided mode of the module) as well as when the students completed an intervention probe (i.e., engaged with the independent mode of the module). Both procedural fidelity checklists are available upon request from the authors. Researchers calculated procedural fidelity as 100% for each of the students during intervention sessions and intervention probes.

Social Validity

After students completed the study, researchers asked students and their teacher questions related to social validity. Specifically, students answered the following questions: a) Did you like using the life skills module?; b) Do you think you could use a stove in a real kitchen now?; c) Do you think the virtual modules is something you would like to try to use to learn more life skills?; and d) Is there anything else you would like to tell us? The teacher answered the following questions: a) Do you think your students improved in their skills relative to using a stove?; and b) Do you think the virtual modules are an effective and efficient way to teach life skills to students?

Data Analysis

Researchers analyzed the accuracy and independence data via visual analysis as well as conducted calculations consistent with single case research design studies (Ledford & Gast, 2018). Researchers graphed the data with Excel and compared the phases of the graphed data. Specifically, researchers examined the graphed data for both immediacy of effect as students transitioned from baseline to intervention and overlap between baseline and intervention data. Researchers also conducted the split middle technique to find the trend for baseline and intervention. To do so, researchers found the median and then mid-rate and mid-date for both phases and connected the mid-rate and mid-date with a line to determine if the data were accelerating, decelerating, or zero-celerating (White & Haring, 1980). Researchers used the median to determine stability, noting data as stable if 80% fell within 25% of the median for each phase (Ledford & Gast, 2018). Researchers also calculated the effect size of the intervention for each participant. Using an online calculator (http://singlecaseresearch.org/calculators/tau-u), researchers determined the Tau-U (Vannest et al., 2011).

Results

The researchers found a functional relation between the intervention of the virtual simulation and the dependent variable of independent accuracy for all three students (see Figure 2 and Table 1). Each of the three students achieved 100% independent accuracy for two consecutive

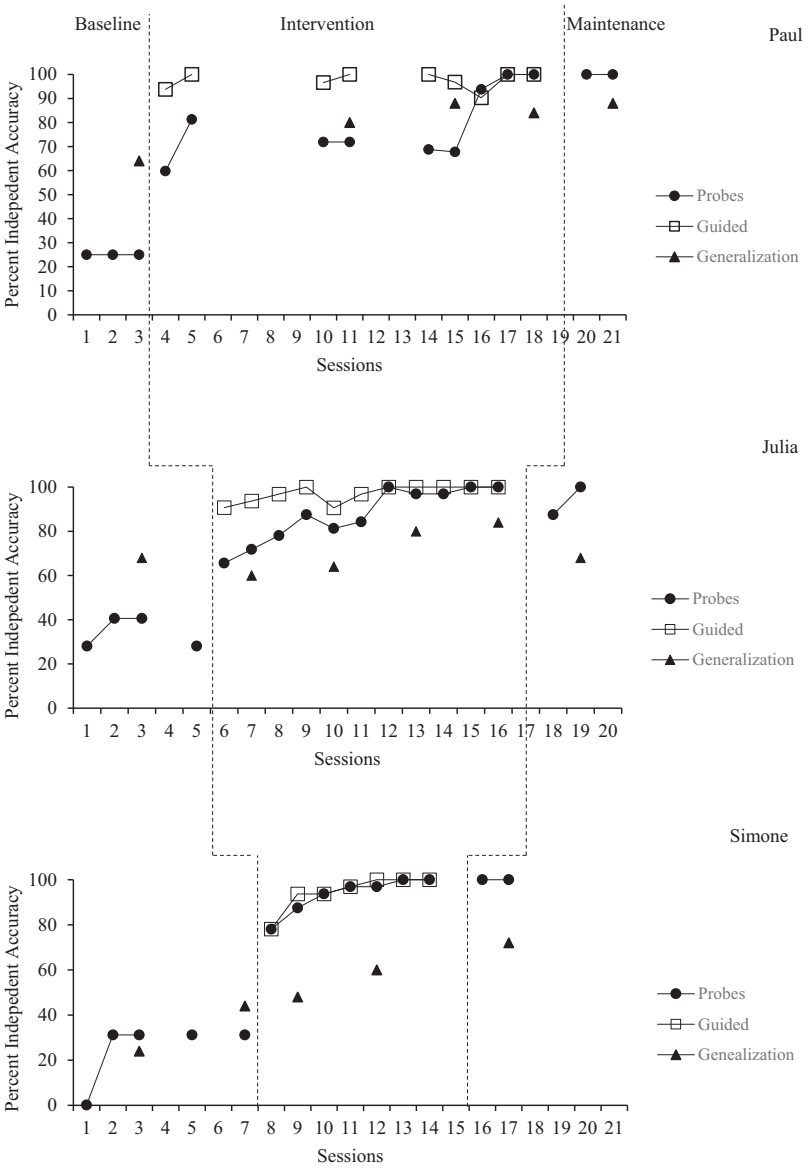

Figure 2. Graphs of Student Independent Accuracy of Making Grilled Cheese.

sessions. The intervention was relatively efficient, with students completing 11 sessions at most. All students also generally maintained their accuracy, with each achieving 100% accuracy at least one of the two maintenance sessions.

Paul

Paul's accuracy during baseline was 25%; he had a zero-celerating trend and stable baseline data. His average task completion time during baseline was 1 min 10 s. Paul met mastery criteria in nine intervention sessions. He experienced an immediate effect in his first intervention session—going from 25% accuracy to 59.8%. Paul's intervention data were accelerating but variable. The Tau-U between his baseline and intervention data was 1.0. Paul's average task completion time during intervention probes was 1 min 28 s. He needed

TABLE 1

Dependent Variables Across Students Across Phases

	Paul	*Julia*	*Simone*
Baseline			
Range and Average of Independent Accuracy	25% ($\mu = 25\%$)	28.1%–40.6% ($\mu = 34.4\%$)	.10%–31.2% ($\mu = 25\%$)
Range and Average of Task Completion Time	1:06–1:13 ($\mu = 1:10$)	1:08–2:02 ($\mu = 1:31$)	1:20–2:30 ($\mu = 1:55$)
Intervention			
Range and Average of Independent Accuracy of Probes (Guided)	90.3%–100% ($\mu = 79.5\%$)	90.7%–100% ($\mu = 97.2\%$)	78.1%–100% ($\mu = 94.6\%$)
Range and Average of Task Completion Time of Probes (Guided)	1:03–2:10 ($\mu = 1:16$)	1:48–2:40 ($\mu = 2:15$)	1:05–3:20 ($\mu = 2:22$)
Range and Average of Number of Prompts (Guided)	0-2 ($\mu = .22$)	0-1 ($\mu = .27$)	0-5 ($\mu = 1.1$)
Range and Average of Independent Accuracy of Probes (Independent)	59.8%–100% ($\mu = 97.5\%$)	28.1%–100% (87.5%)	78.1%–100% ($\mu = 93.3\%$)
Range and Average of Task Completion Time of Probes (Independent)	1:03–3:10 ($\mu = 1:28$)	1:12–3:00 ($\mu = 1:58$)	1:30–3:20 ($\mu = 1:44$)
Range and Average of Number of Prompts (Independent)	0-1 ($\mu = .22$)	0-1 ($\mu = .18$)	0-1 ($\mu = .17$)
Maintenance			
Range and Average of Independent Accuracy	100% ($\mu = 100\%$)	87.5%–100% ($\mu = 93.8\%$)	100% ($\mu = 100\%$)
Range and Average of Task Completion Time	1:12–1:23 ($\mu = 1:18$)	1:24–1:25 ($\mu = 1:25$)	1:06–1:11 ($\mu = 1:09$)
Generalization			
Range and Average of Independent Accuracy	64%–88% ($\mu = 80.8\%$)	60%–84% ($\mu = 70.7\%$)	24%–72% ($\mu = 49.6\%$)
Range and Average of Task Completion Time	1:07–1:52 (1:42)	1:40–2:55 ($\mu = 2:21$)	3:30–5:00 ($\mu = 4:21$)

one prompt each in the first two intervention sessions but none afterwards. When Paul struggled during the intervention probe, the task analysis steps he tended to get incorrect responses on involved predominately waiting for the sandwich to cook on both sides and then flipping within the allotted time as well as taking the hot pan off the heat at the end. Paul's accuracy during his guided sessions ranged from 90.3%-100%. Paul was 100% accurate for both maintenance sessions with an average task completion time of 1 min 18 s. Of note, Paul experienced multiple breaks during his intervention phase due to catching COVID and then due to suspension. He experienced a large gain between his first and second intervention sessions (59.8% to 81.3%) and then was gone for two weeks. He dropped back to 71.9% independent accuracy. Paul's generalization scores ranged from 64% (during baseline) to 88% during intervention and maintenance.

Julia

Julia's accuracy during baseline was 34.4%; she had a zero-celerating trend and stable baseline data. Her average task completion time during baseline was 1 min 31 s. Julia met mastery criteria in 11 intervention sessions. She experienced an immediate effect in her first intervention session—going from 28.1% accuracy to 65.6%. Julia's intervention data were accelerating and stable. The Tau-U between her baseline and intervention data was 1.0. Julia's average task completion time during intervention was 1 min 58 s. She needed one prompt for her first intervention session and then again in session 8. When Julia struggled during

the intervention probe, the task analysis steps she responded to incorrectly involved waiting for the sandwich to cook on both sides and flipping within the allotted time as well as taking the hot pan off the heat at the end. Julia's accuracy during her guided sessions ranged from 90.7%-100%. Julia was 100% accurate for her second maintenance session but 87.5% for her first intervention session, with an average task completion time of 1:25 across the two. Julia's generalization scores ranged from 60% (during intervention) to 84% (also during intervention).

Simone

Simone's accuracy during baseline was 25%; she had a zero-celerating trend and stable baseline data. Her average task completion time during baseline was 1 min 55 s. Julia met mastery criteria in seven intervention sessions. She experienced an immediate effect in her first intervention session—going from 31.2% accuracy to 78.1%. Simone's intervention data were accelerating and stable. The Tau-U between her baseline and intervention data was 1.0. Simone's average task completion time during intervention was 1 min 44 s. She needed one prompt for her fourth intervention session. Like Paul and Julia, Simone's incorrect answers during intervention probes involved waiting for the sandwich to cook on both sides and flipping within the allotted time as well as taking the hot pan off the heat at the end. Simone's accuracy during her guided sessions ranged from 78.1%-100%. Simone was 100% accurate for both maintenance sessions with an average task completion time of 1 min 8 s across the two. Simone's generalization scores ranged from 24% (during baseline) to 72% (during maintenance).

Social Validity

Two of the three students felt like they improved in the skill of making a grilled cheese sandwich on the stove following the virtual simulation intervention. Simone felt she did not gain in the skill because she occasionally burned the grilled cheese. However, Simone gained the skill in the fewest number of intervention sessions as well as achieved 100% for two intervention sessions as well as maintained accuracy at 100%. Both Paul and Julia also felt they could make a grilled cheese sandwich on a real stove; Simone was worried she would burn it in real life. Simone and Julia felt they could make macaroni and cheese on the stove following the virtual simulation. Both Paul and Julia felt they enjoyed using the simulation to learn the life skill; Simone was more apprehensive in her response. However, the teacher reported all three students looked forward to the researchers coming, expressed enjoyment of the sessions when in the classroom, and spoke positively of the simulations to her and other students.

Discussion

Life skills represent important skills needed for students with IDD. Researchers have evaluated the efficacy of multiple interventions in supporting the acquisition of life skills for students with IDD, including technology-based options. In this study, researchers examined a virtual simulation for delivering life skills modules to students with disabilities. The researchers concluded two main results: (a) a functional relation was found between the intervention—virtual simulations for delivering life skills instruction—and the dependent variable of independent accuracy in making a grilled cheese sandwich on a stove; and (b) students maintained high levels of accuracy in their targeted life skill.

All three students made significant gains in their accuracy of making a grilled cheese sandwich on the stove from baseline to intervention and the intervention was relatively efficient. The students were all below 50% accuracy during baseline and achieved two consecutive sessions at 100% accuracy, in a range of 7-11 sessions. As such, the virtual simulation intervention was both effective and efficient. The virtual simulation represents non-immersive virtual reality (VR) or virtual environments (Carreon et al., 2022). Within a recent review of virtual reality research involving students with disabilities, most the existing research base represents non-immersive VR; however, limited attention is given to life skills (Carreon et al., 2022). The existing life skills VR research focuses on safety (e.g., crossing

the street; fire drill responses), exercise, or vocational skills (e.g., sorting; Carreon et al., 2022).

Of note, when students struggled, all three tended to inaccurately complete the same steps—cooking the sandwich for the sufficient time, flipping the sandwich in time (before it burned one side), and removing the hot pan from the heat after the sandwich is cooked and put on the plate. Cooking the sandwich on a side for the sufficient time and then flipping it before it burned represented two of the least authentic task analysis steps. For example, a green progress bar appeared to indicate when students should flip, which, during guided, was said to reflect 2 min (i.e., took less than 20 seconds). The system did not have students set a timer, as in other modules (e.g., the oven to make frozen pizza) but relied on the green progress bar that would not exist in real life. Further, the green progress bar moved so fast, it was initially difficult to pick up the spatula and flip the sandwich before the progress bar turned red, at which time smoke appeared from the pan and the virtual simulation informed the students something was burning. The virtual simulation should be adjusted to incorporate a timer and utilize more realistic timing to support generalization. Further, students could be taught to check on the cooking of the sandwich and attend to the color of the toasted bread, which is also more realistic.

Although the research base of VR is still emerging for students with disabilities, particularly students with IDD, other researchers suggest the potential to support students in particular context—similar to the original inception of the virtual life skills modules. Researchers have suggested VR tools, such as the virtual simulation intervention examined in this study, can support students with disabilities in rural settings or those who have more limited access to real life experience within a school setting (Gallegos et al., 2022). Other researchers noted the potential of VR specifically for students with IDD given the opportunity to engage in a task within a safe environment, which is applicable to cooking (Park et al., 2023).

In addition to students' acquiring the skill of making a grilled cheese sandwich on a stove, students maintained this life skill after intervention ended. Each of the students had at least one maintenance session at 100%, with Paul and Simone earning 100% accuracy for both of their maintenance sessions. Although students were able to maintain the skill without instruction proceeding, students had less success with generalizing their success with making a grilled cheese on a stove within the virtual simulation to making a frozen pizza in the oven within the virtual simulation. Paul and Julia were able to achieve over 80% accuracy, with Simone reaching over 70%. This is not necessarily surprising as making an item on the stove is not the same as making it in the oven. However, researchers noted the generalization of some cross-over task steps between the two life skills modules (e.g., washing hands, use of a tool—spatula or oven mitt—for hot items). A more appropriate generalization examination would be to have students cook something else on the stove within the virtual simulation, which was not possible, or to have students make a real grilled cheese sandwich on a real stove, which was also not an option at the school (Collins, 2012; Jimenez et al., 2019).

Limitations and Future Directions

One limitation of this study was the lack of an in vivo generalization phase. While the acquisition and maintenance of making a grilled cheese sandwich on a stove within a virtual environment is important as it represents the obtainment of independent living skills by secondary students with IDD, it is important to have students demonstrate said skills in genuine contexts. Unfortunately, a stove was not available to use within the school. Future researchers should seek to purposefully examine the generalization of the acquired skill to real life applications. Another limitation involves that Paul had two gaps within his intervention phase. First, he contracted COVID and was out for almost 2 weeks and then he was suspended for behavioral concerns for another week. Despite these gaps, he was able to achieve mastery within nine sessions, which was less than Julia, who engaged in 11 intervention sessions. Additionally, a potential limitation was that the students did not have independent living postsecondary goals specifically involving cooking. However, the baseline sessions indicated

the students were not proficient with regards to this particular life skill. In the future, researchers should focus on life skills goals as the target for intervention. Finally, the researchers probed for acquisition immediately after the intervention as well as implemented the SLP for non-responses. In the future, researchers may seek to explore delayed probing as well as eliminate the SLP.

Implications for Practice

An implication of this study is the efficacy and efficiency of teaching life skills—in particular food preparation life skills—via a virtual simulation. Not all schools and students have access to learn food preparation life skills in vivo. Based on this study, virtual simulations—or non-immersive VR—provides an opportunity for teachers to help students with IDD acquire and maintain these skills in limited relatively few intervention sessions with only a computer. Teachers in a variety of settings can provide students with IDD an opportunity to learn food preparation skills in a safe environment before engaging in real life to help students gain skills that can support their independent living.

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